



Collective Mind:



Continuous, Automatic Learning to Improve Equipment Maintenance A Request for Guidance

CBM+
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Vision: New Paradigm for Maintenance Decision

Supportive: Actively Manage the Maintenance Process

Operating at All Levels, All Phases of Operations

Continuously Improve Planning, Response, and Execution

Integrating all Elements into a Living, Distributed, Global Maintenance

Technical Approach

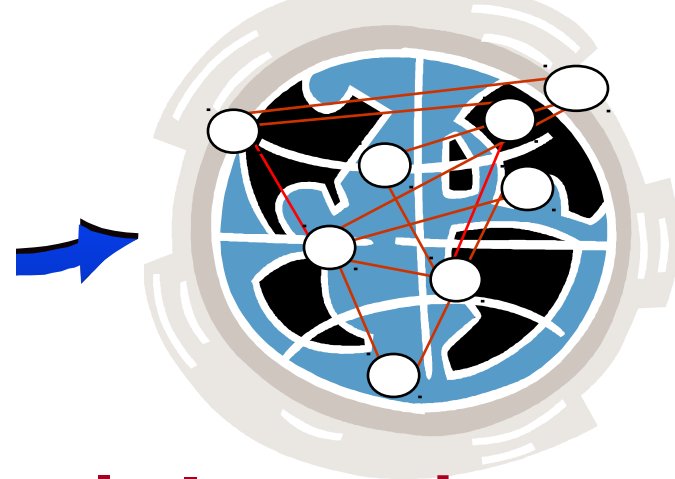
Basic Building Block:
Self-Aware Platform



Collective Mind:
Communities of Self-Aware Platforms



Sense and Respond
Maintenance Network



Global Community of Continuously Improving Equipment



Self-Sustainment Requirement

- Army Future Force units in 2020
- Air Expeditionary Force
- Navy/Marines Sea Basing

Army: “The UA is self-sustainable for 3-7 days of operations and maintains combat power with dramatically reduced theater stockpiles.”

Critical Capabilities: Reliability
Prognostics



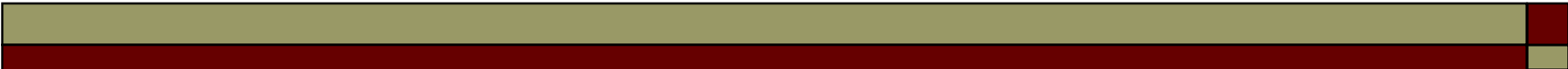
Challenges for Prognostics

- ❑ Lack of Physics of Failure models
- ❑ Missing sensor suites
- ❑ Low equipment-utilization rates
- ❑ etc.

But Maintenance Crews

- ❑ Have the ability to improve reliability of their equipment over time

We have yet to tap the data we have!



Claim: Existing field experience can be used to improve

- ## Prognostics
- Discover similar units
 - Peers form a “Collective”
 - Evaluate unit under consideration using experience of the Collective
 - Improve discovery and evaluation methods based on weapon systems success
 - Learning gives us our title “Collective Mind”

Key Technology: Statistical Machine Learning

Example: Locomotive

The Mission:

Select 12 Locomotives
to go from CA to PA



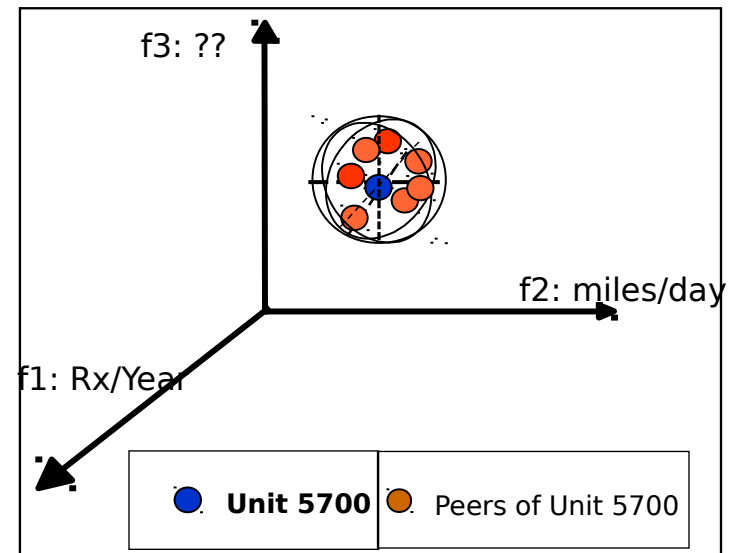
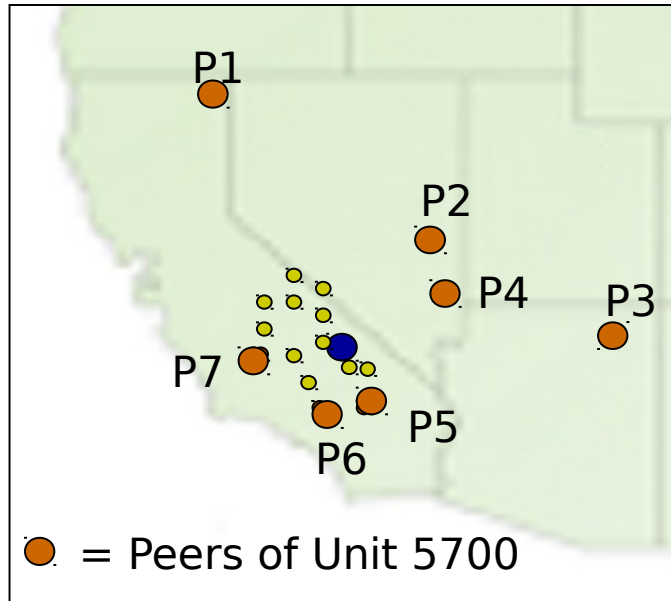
Data from GE Transportation
Locomotives Network Enabled

Decision Support

Data:

200+ Basic Parameters	
Design and Configuration	
Type	
Electrical System	
...	
Utilization Information	
Age	
Mileage	
Average miles/day	
...	
Maintenance Information	
Time elapsed since last repair	
Median time between repairs	
Median time from repair to next recommendation (Rx)	
...	

Identifying Peers



Collective: Peers with similarity measure
Peer experience forms Mission Reliability
(MR) rank

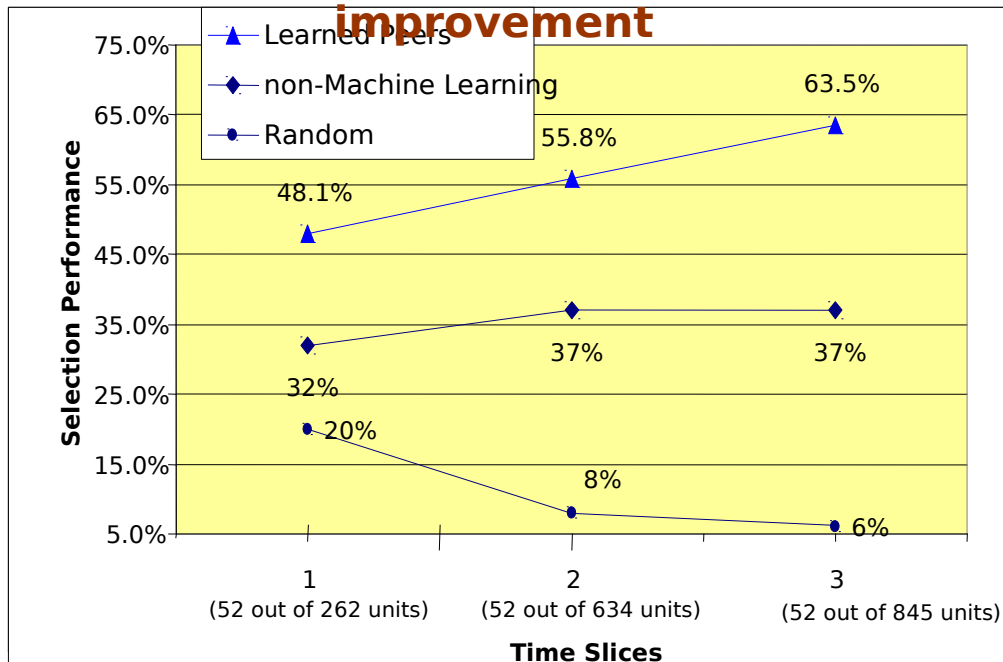
Learning: similarity measure updated by
accuracy of MR Rank

State of the Practice: non-Machine Learning

Selection Criteria	% of Correctly Classified Units: Top 20% (Sample Performance)
Lowest Mileage	17%
Newest Units	18%
Random	20%
Highest Energy (MWHRS) generated	24%
Highest Miles/ Hours Moving	26%
Highest Percentage Hours Moving	29%
Lowest Percentage of Failures in Most Critical Subsystem	38%
Lowest Ratio: Recommendations / Age	49%

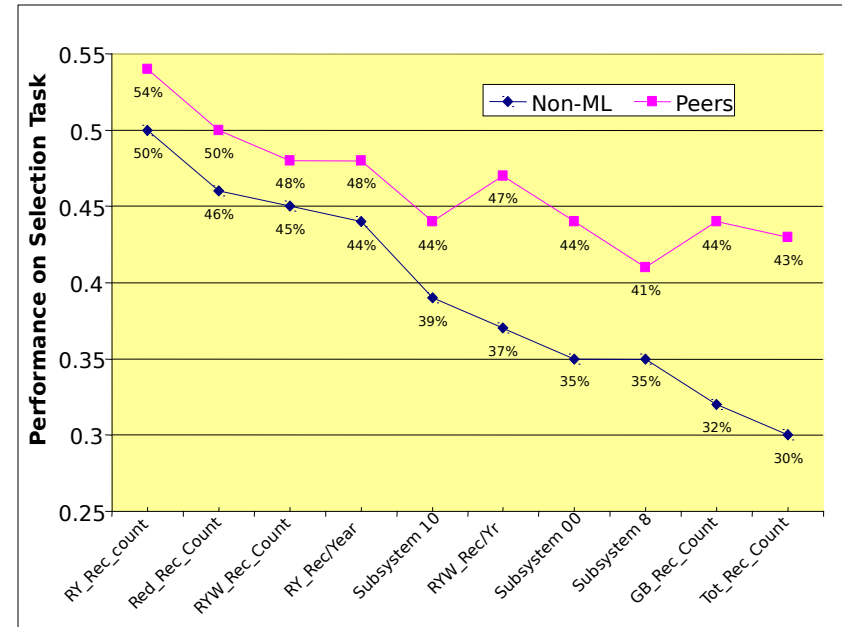
Accuracy and Robustness of the Peer Approach

Learned Peers show better performance & continuous improvement



Excellent Performance with Existing Sensors on Legacy Systems

Highest contributing parameters assumed missing



Robust to Missing Information



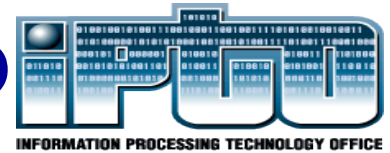
Guidance

□ Possible Futures

- Test in of Current Technology in Services
 - Proposals with AFRL to eLog21: F110 or F100
 - Partnership with AMCOM, Fort Rucker: Blackhawk
- Development of Technology
 - Meeting with ONR and Marines ALP
- Development of Vision
 - Meeting with DARPA IXO



Questions?



Collective Mind

Continuously Improving Equipment Maintenance

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